



Evaluation of Multiple Flow Constrained Area Capacity Setting Methods for Collaborative Trajectory Options Program

Presented by Gita Hodell

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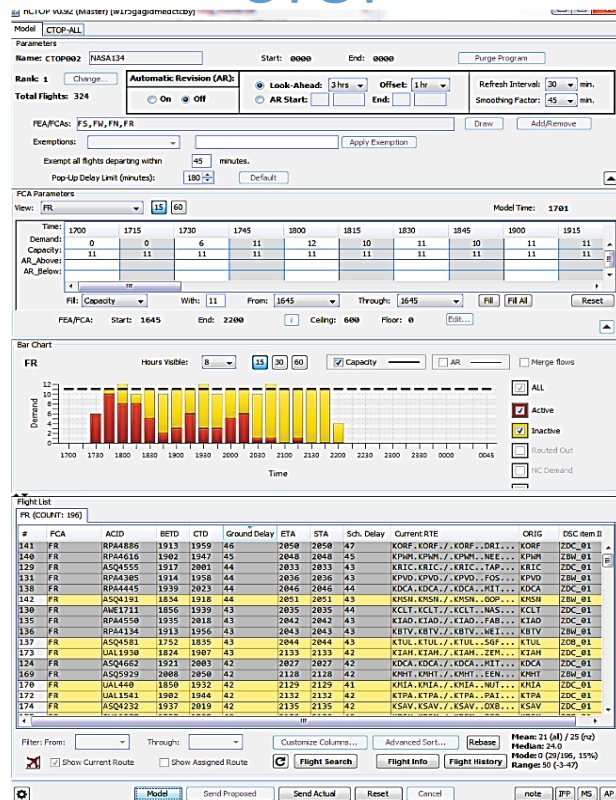
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Background

Integrated Demand Management (IDM)

- Collaborative Trajectory Options Program (CTOP)
- Time Based Flow Management (TBFM)

CTOP



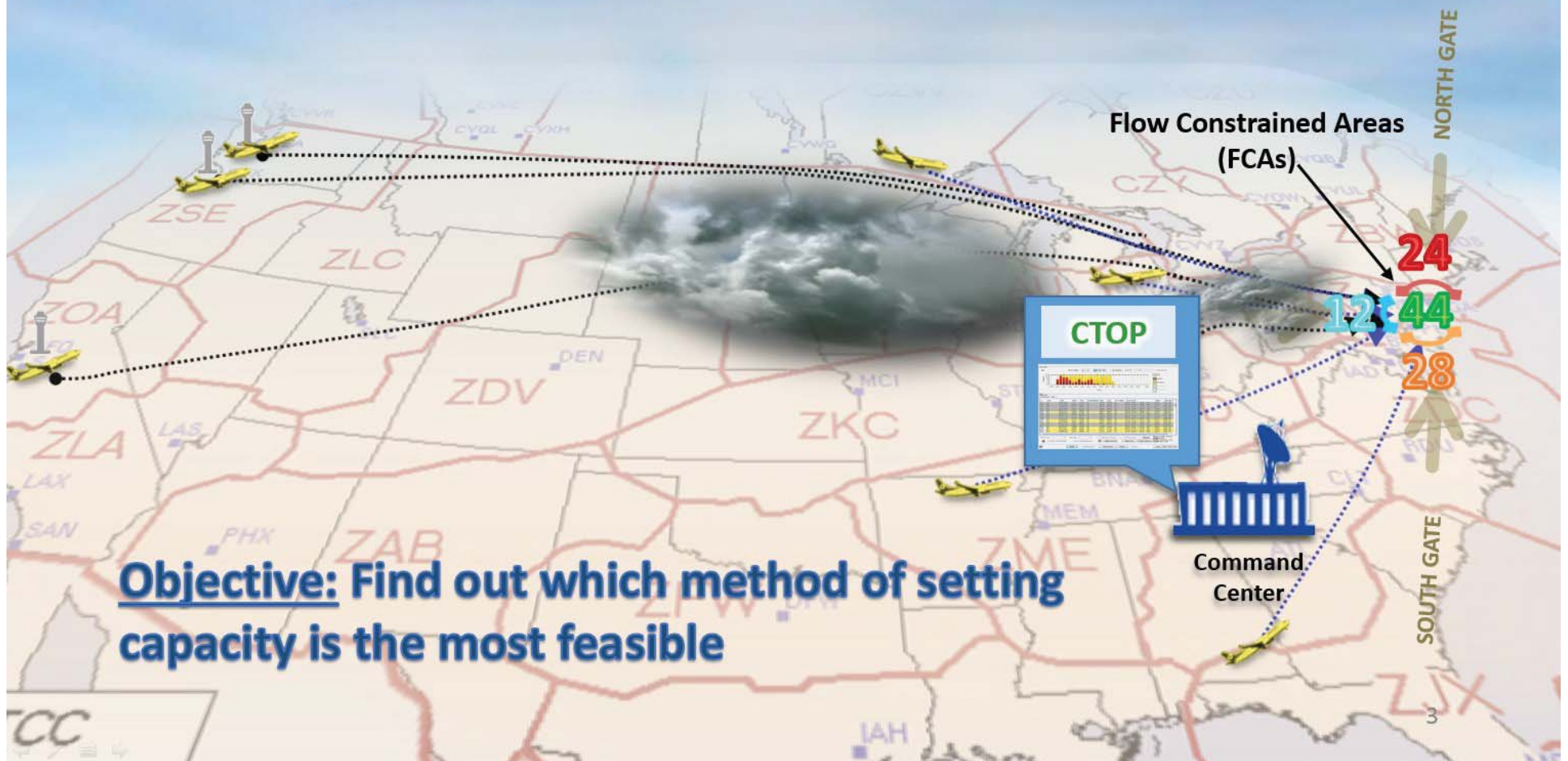
TBFM



IDM scenario

Motivation: Manage airspace and airport constraints in an integrated manner

Objective: Find out which method of setting capacity is the most feasible



CTOP interface: Manual

CTOP: EWR Set Start: now End: +12 Purge Program

Rank: 1 Change... Automatic Revision (AR): ☐ On ☒ Off

Look-Ahead: 3 hrs Offset: 1 hr Refresh Interval: 30 min Smoothing Factor: 45 min

FEA/FCAs: _STH,_WTH,_NTH Draw Add/Remove

Exemptions: Exempt all flights departing within 45 minutes. Pop-Up Delay Limit (minutes): 180 Default

FCA Parameters View: _WTH 15 60 Model Time: 24/1836

Time	1830	1845	1900	1915	1930	1945	2000	2015	2030	2045
Demand	0	0	2	2	2	2	2	6	7	2
Capacity										
AR_Above										
AR_Below										

Fill: Capacity With: From: 1830 Through: 1830 Fill Fill All Reset

FEA/FCA: Start: now End: +12 Ceiling: 600 Floor: 0 Edit...

Bar Chart _WTH Hours Visible: 5 15 30 60 ☒ Capacity ☒ AR ☒ Merge flows

_WTH Demand (actual)

ALL ☒ Active ☒ Inactive ☐ Routed Out ☐ NC Demand ☐ CTD ☐ Exempt Other

Flight List _WTH (74)

#	FCA	ACID	cETA	BETD	CTD	Gr...	A...	BETA	CTA	Current RTE	ORIG	I
01	FW/WTH	JTL393	24/2233	24/2114	24/2114	0	0	24/2234		KIND./..BDOCK..KLYNE..DORE..KIND	ZI	
02	FW/WTH	UAL1640	24/2101	24/1833	24/1833	0	0	24/2101		KLAX./..LBF087055..DAG.J10..KLAX	ZI	
03	FW/WTH	ASA14	24/2316	24/1834	24/1834	0	0	24/2317		KSEA./..TCM034022..GEP..OD..KSEA	ZI	
04	FW/WTH	N420MP	24/1952	24/1853	24/1853	0	0	24/1954		KFDY./..SLT.FOM3.KWR	KFDY	ZI

Filter: From: Through: rd Customize Columns... Advanced Sort... Rebase No delays.

☒ Show Current Route ☐ Show Assigned Route Flight Search Flight Info Flight History

Model TOS Algorithm Send Actual Reset Cancel note

CTOP interface: Automated - FCA Balancing Algorithm (FBA)



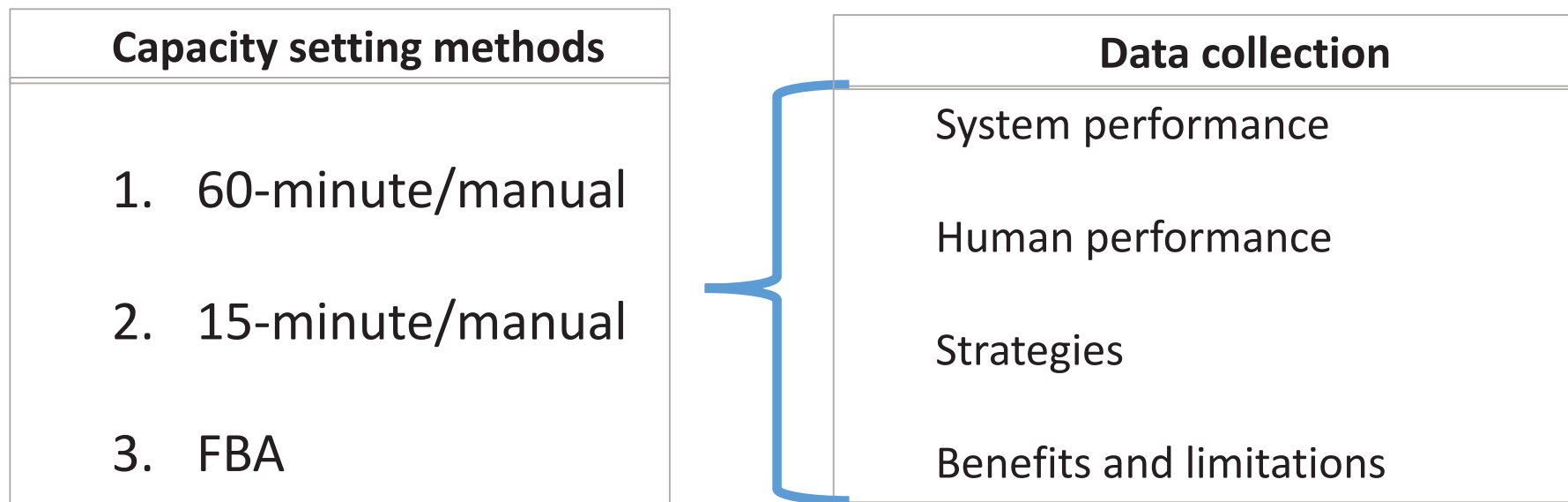
Research Questions

Manual vs. FBA

- Are either or both of these methods **feasible**?
- How do they compare in terms of **system performance**?
- How do they compare in terms of **human performance**?
- Are there different **user strategies** associated with different methods?
- What are the **benefits and limitations** of using different methods?

Experimental design

- Part-task Human in the Loop simulation
- Single factor design



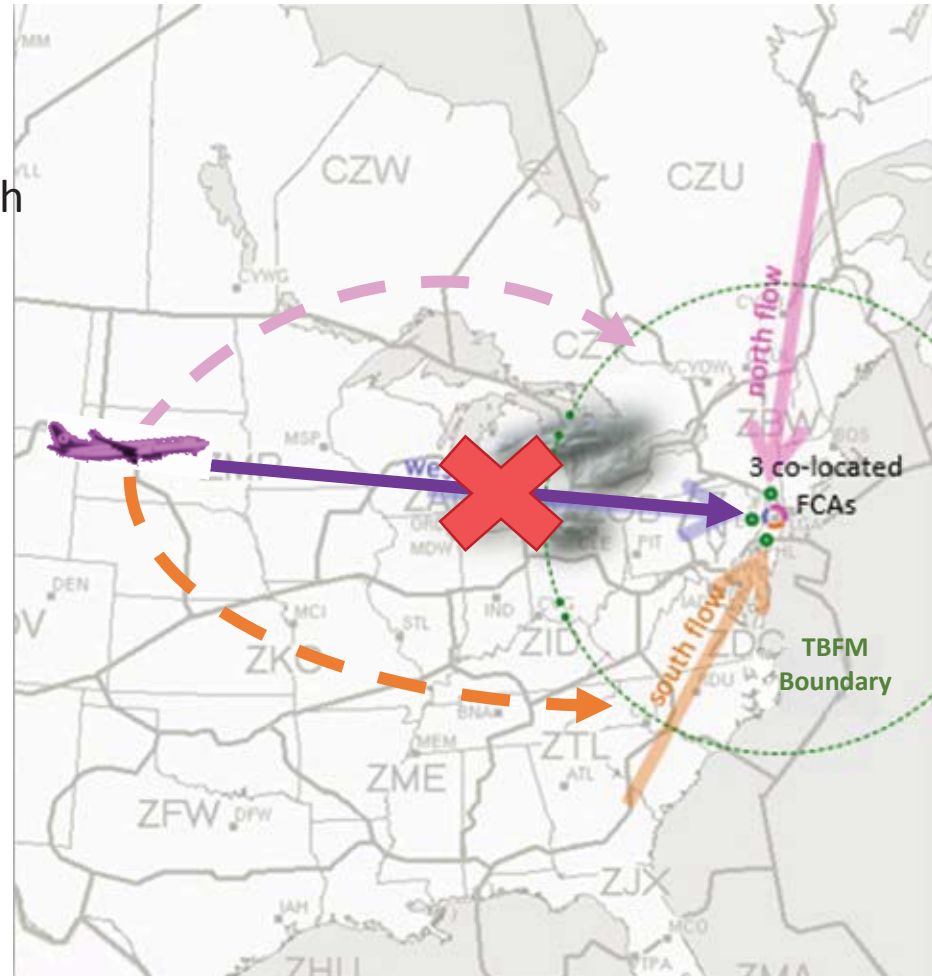
Scenario characteristics

Scenario:

- Newark arrivals
- Heaviest flows from the west and south
- West gate is limited to 12 flights/hour

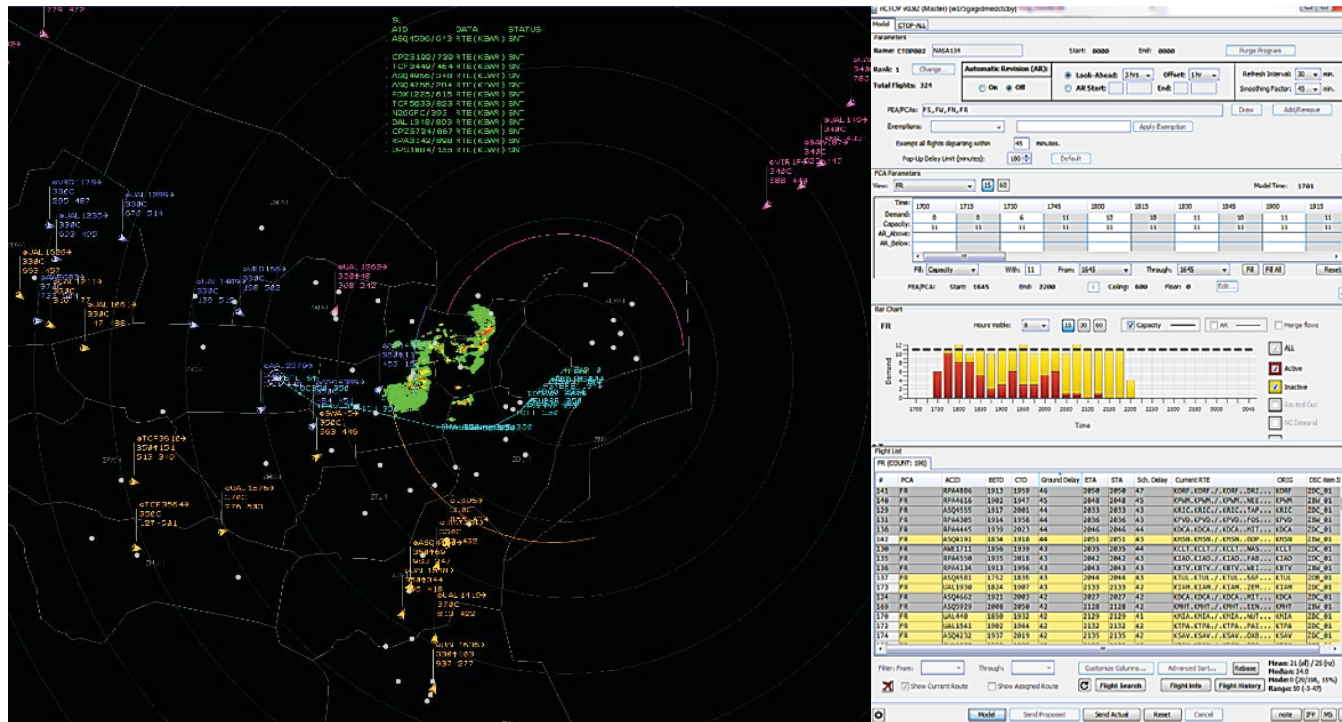
Trajectory Option Sets: (TOS)

- Pre-departure reroutes



Tools

- *MACS*: The Multi-Aircraft Control System (MACS)
- *nCTOP*: CTOP emulation software
 1. Fielded CTOP configuration
 2. Enhanced nCTOP configuration



*Fielded CTOP configuration

60-minute/manual

Time	Original	New	Rate	Remaining	Original	New	Rate	Remaining	Total	%
2245	4	4	3	1	8	8	5	3	12	.67
232	12	13	12	1	19	22	20	2	35	.94
002	11	12	11	1	20	22	21	1	34	.94
012	9	10	12	0	16	17	20	0	27	1.18
022	7	7	16/28		6	6	16/208			

FCA Parameters							
View:	NTH		15	60			
Time:	2100	2200	2300	0000	0100	0200	0300
Demand:	0	7	12	10	9	7	0
Capacity:		3	12	11	12		
AR_Above:							
AR_Below:							



*Fielded CTOP configuration

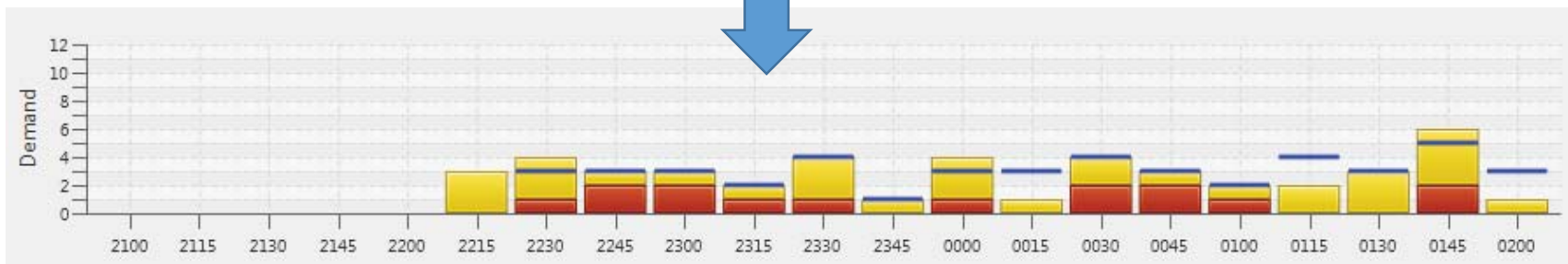
15-minute/manual

Time	Original	New	Rate	Remaining	Original	New	Rate	Remaining	Total	%
2200	4	4	3	1	6	6	5	1	10	.8
15	2	3	2	1	6	7	6	1	10	.8
30	4	5	4	1	4	5	4	1	10	.5
45	1	2	3	0	3	4	5	0	6	1.33

FCA Parameters

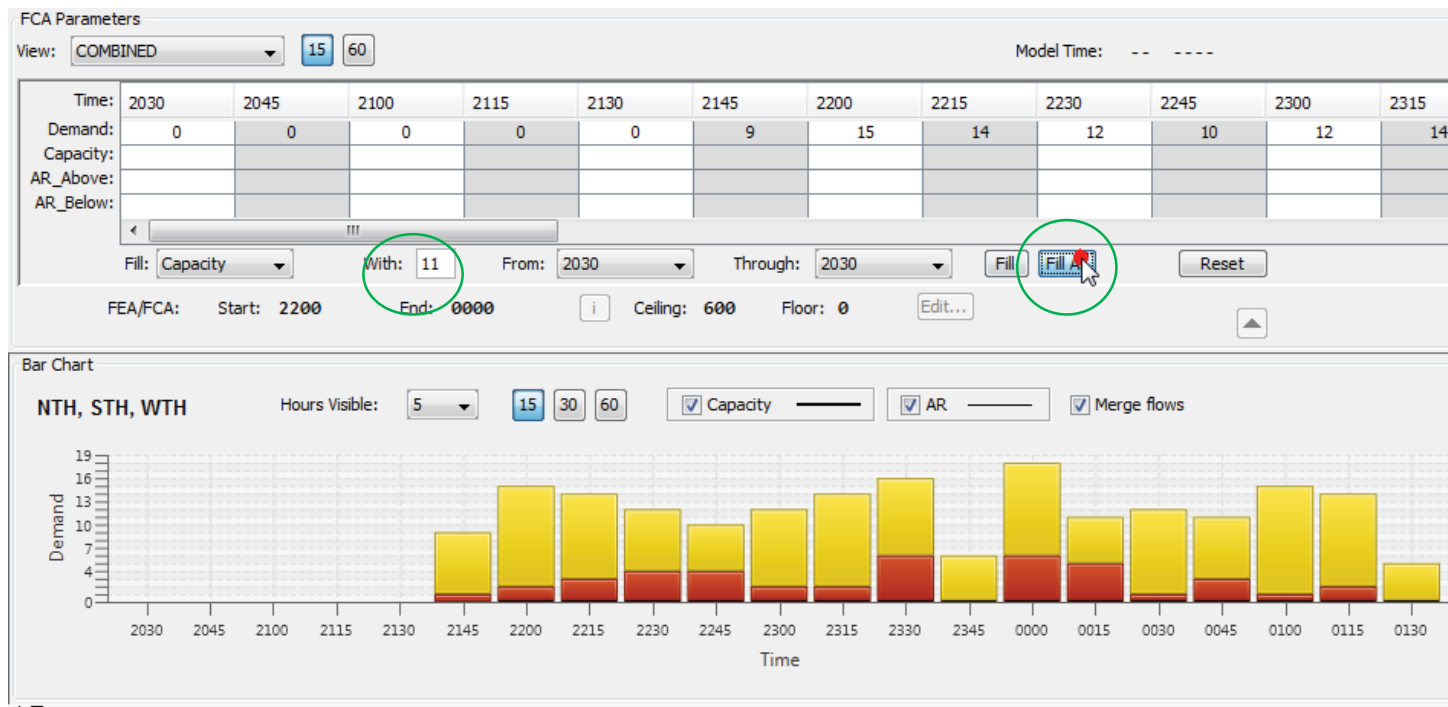
View: NTH 15 60 Model Time: 2108

Time:	2230	2245	2300	2315	2330	2345	0000	0015	0030
Demand:	4	3	3	2	4	1	4	1	4
Capacity:	3	3	3	2	4	1	3		
AR_Above:									
AR_Below:									



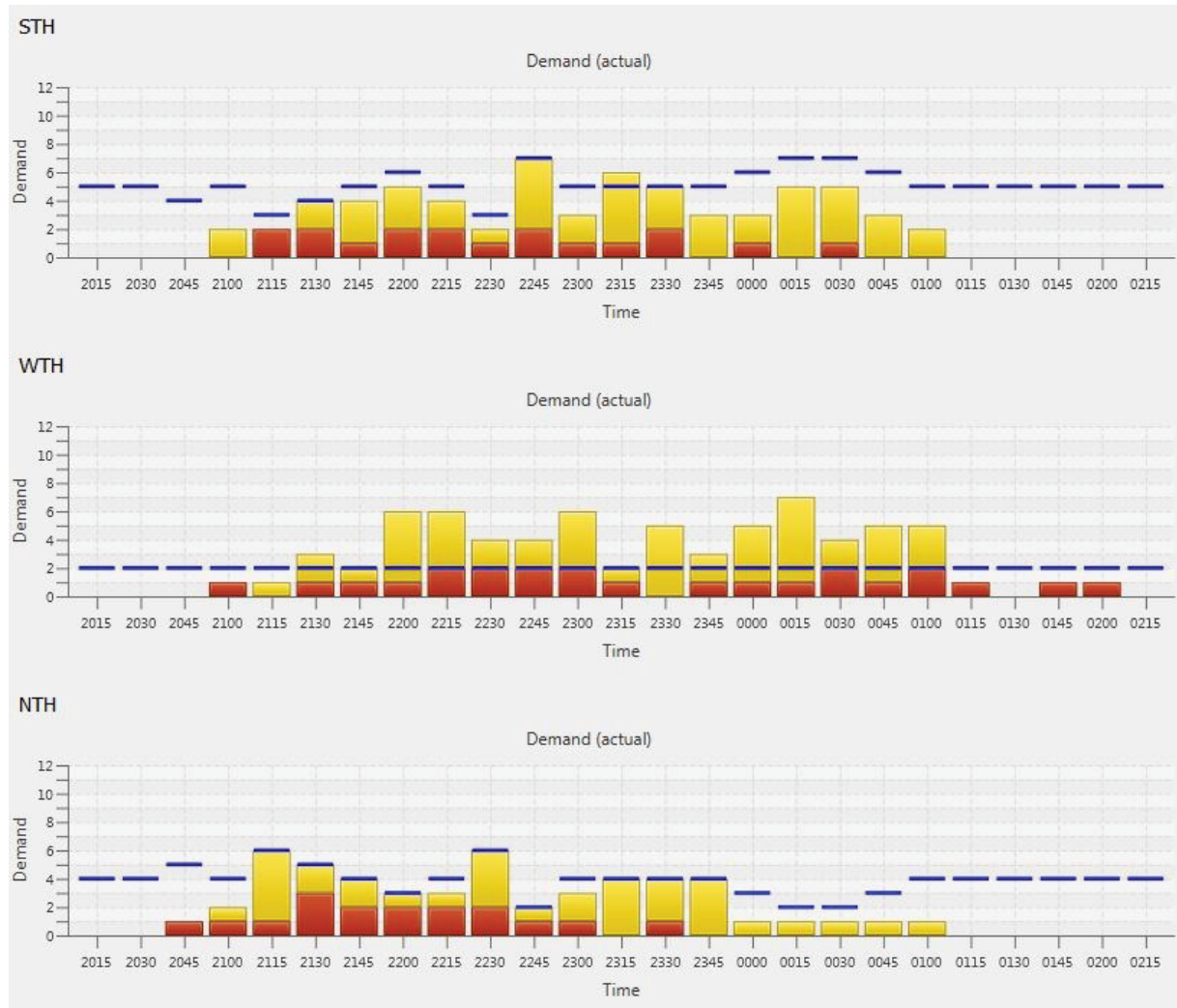
Enhanced nCTOP configuration

FBA



Enhanced nCTOP configuration

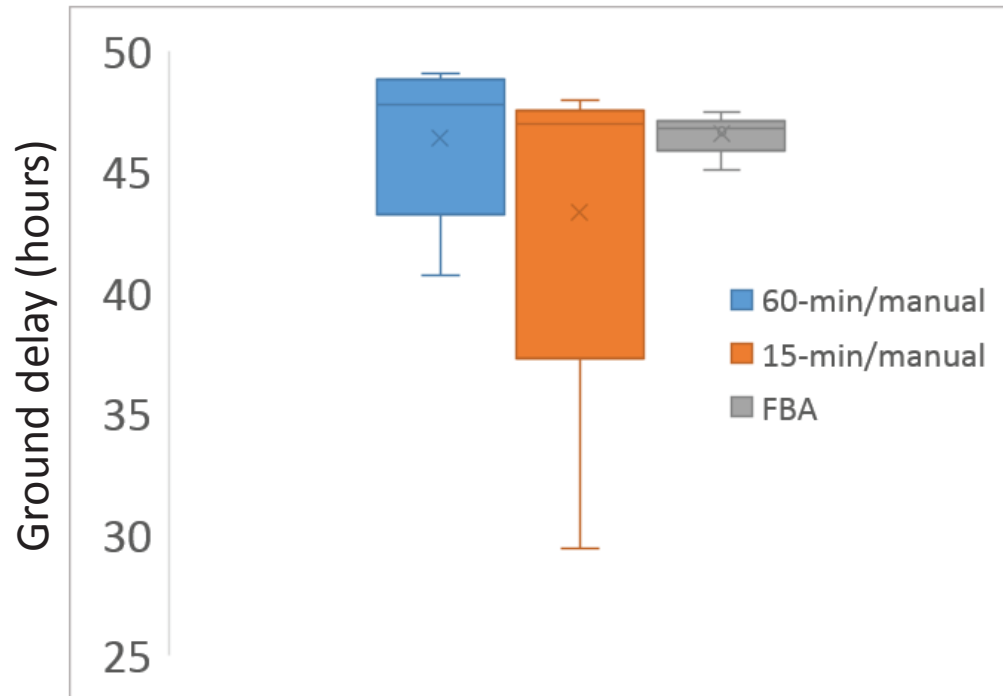
FBA



Results

- System performance
- Human performance
- Strategies
- Benefits and limitations

System performance – total ground delay (hours)



Method	Average	SD	Median
60-min	46.40	3.42	47.80
15-min	43.32	7.84	46.97
FBA	46.56	0.88	46.78

The three methods performed similarly in terms of ground delay.

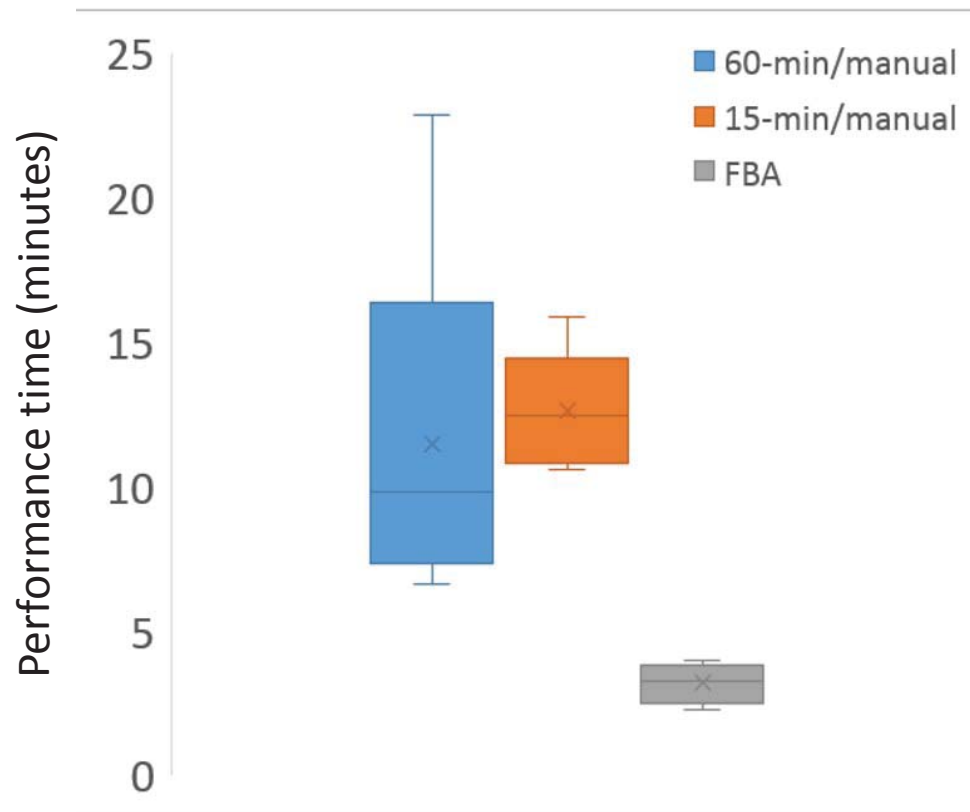
System performance – Airport throughput

- Target arrival rate is 44 flights per hour

Condition	Rate
15-minute/manual	44.25
60-minute/manual	44.5
FBA	44.1

Target arrival rate met in all three conditions

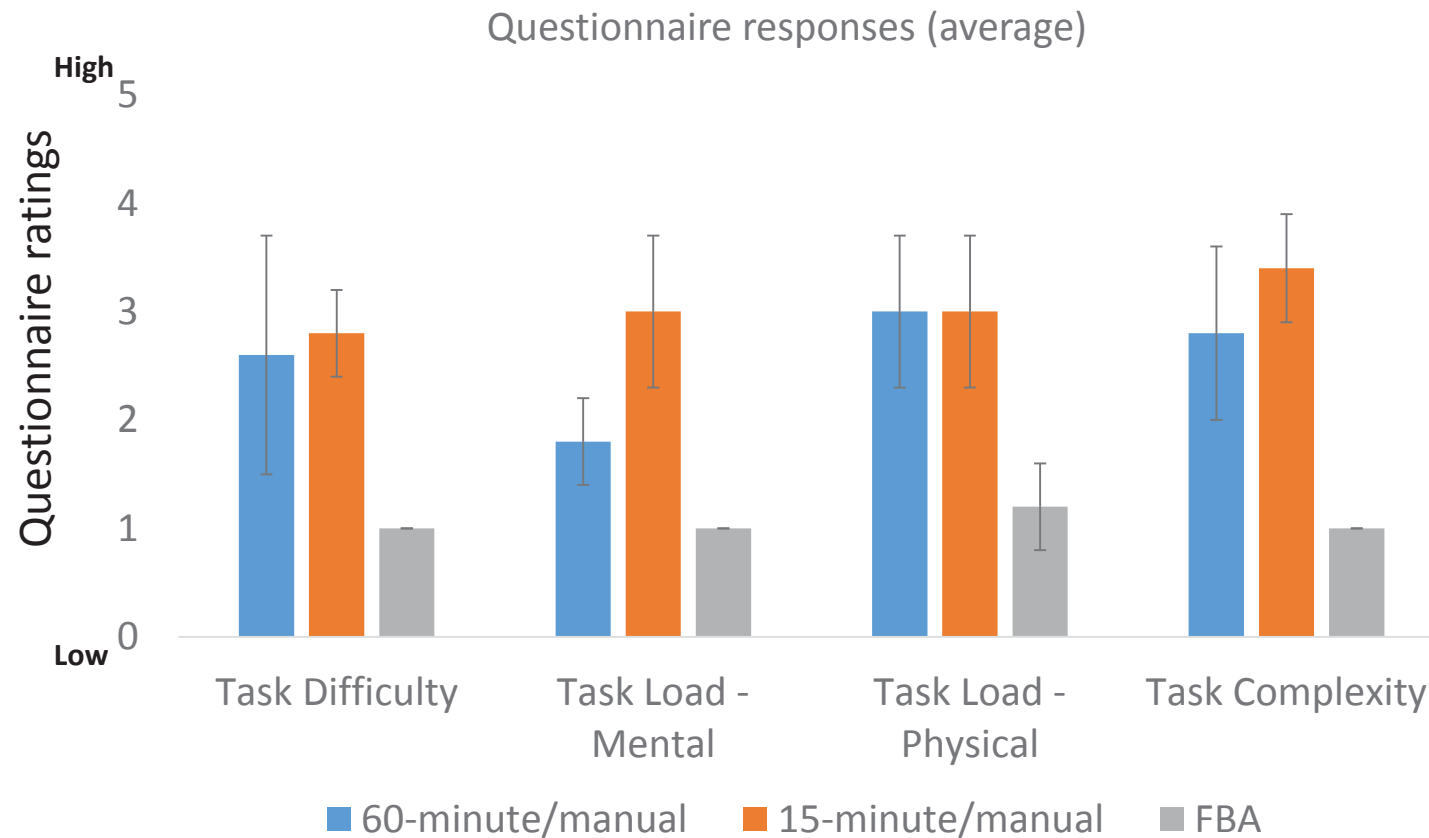
Human Performance – task performance time (minutes)



Method	Average	SD	Median
60-min	11.45	6.51	9.83
15-min	12.60	2.10	12.47
FBA	3.19	0.69	3.25

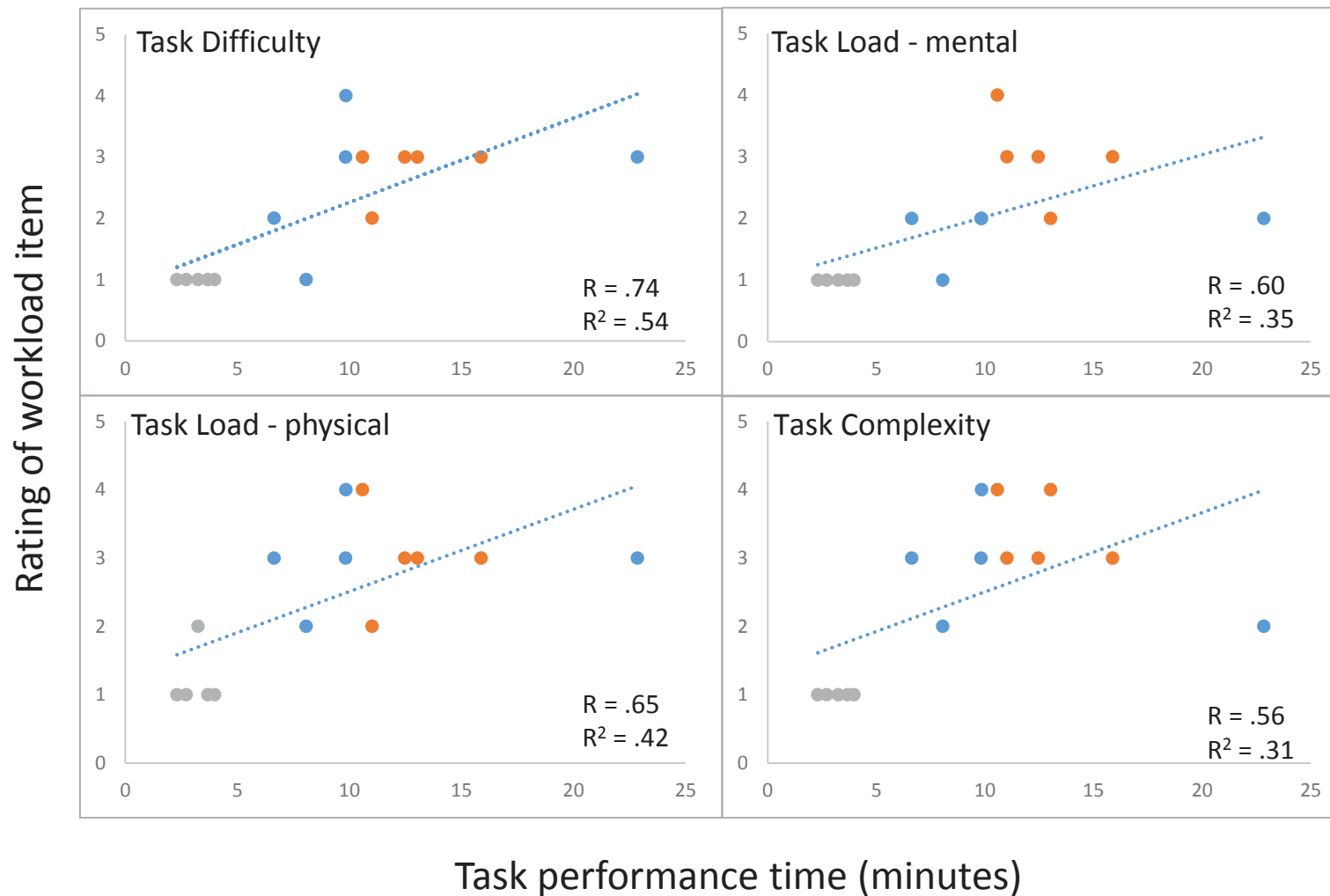
The FBA was the fastest method

Human performance – subjective workload ratings



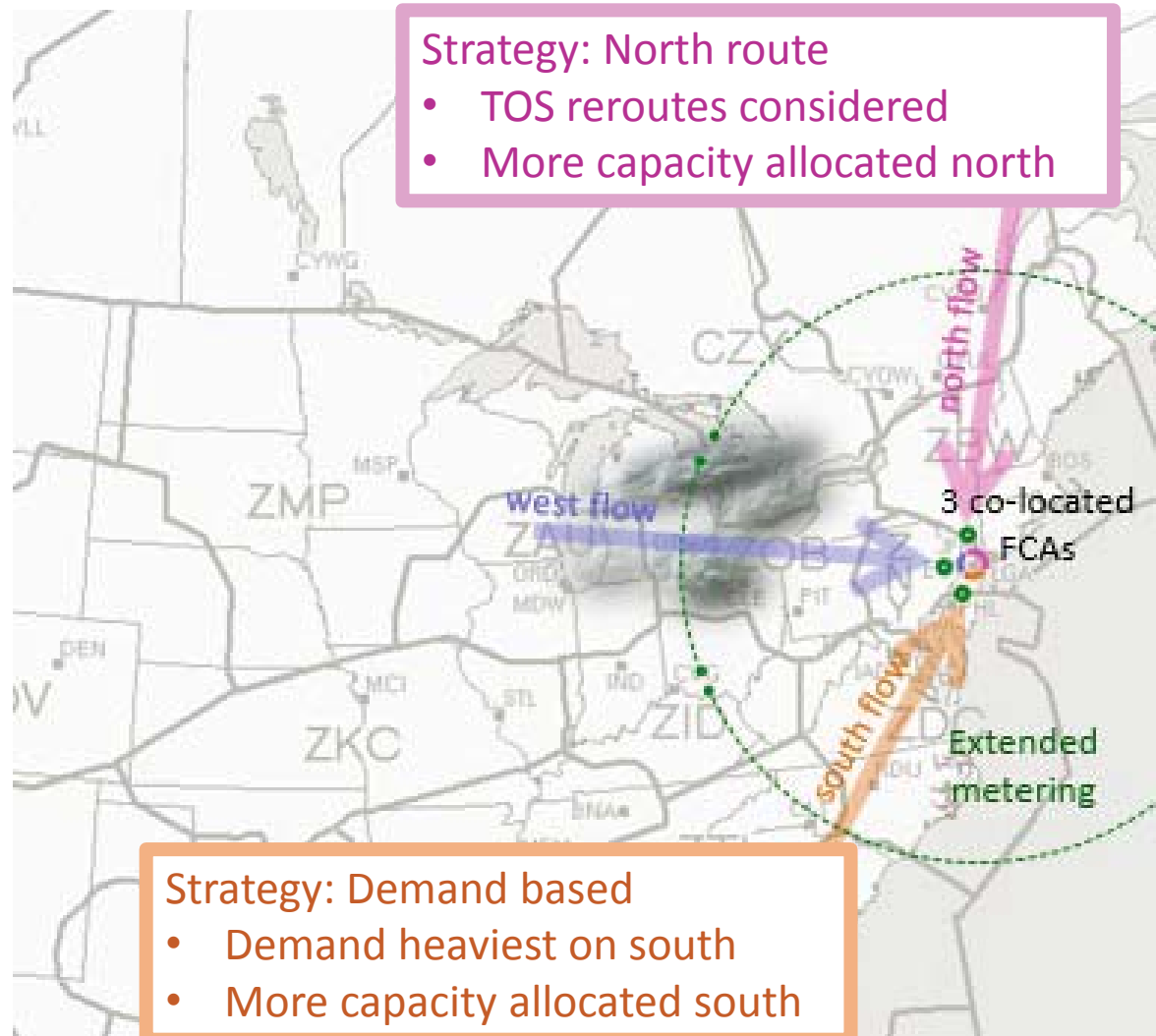
The FBA had the lowest workload ratings of all three conditions

Subjective ratings by performance time correlation



Longer performance times are related to higher workload ratings

Strategy



Comparison of Demand based vs. North route strategies

Slots assigned to FCA	Demand based	North route
North	46	53
South	74	68
West	45	45

System performance	Demand based	North route
Total ground delay (hours)	46.96	29.27
Flight time difference (hours)	3.67	2.93
Number of reroutes	21	21
West to North	9	15
West to South	12	6

Benefits, limitations, and feasibility of different methods

- 60-minute/manual
 - Benefit: Quick and easy
 - Limitation: Precision
- 15-minute/manual
 - Benefit: Precision
 - Limitation: Cumbersome
- FBA
 - Benefit: Quick, easy, and precise
 - Limitation: None

All methods are feasible, but FBA has more benefits and fewer drawbacks

Conclusions

- System performance
 - Similar
- Human performance
 - FBA was superior
- Strategies
 - Varying the strategy causes different outcome
 - Some improvements could be made to the FBA
- Benefits, limitations
 - FBA has more benefits, fewer drawbacks

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